**Assignment for SP226 Due 04/03/00 Name** ______________________

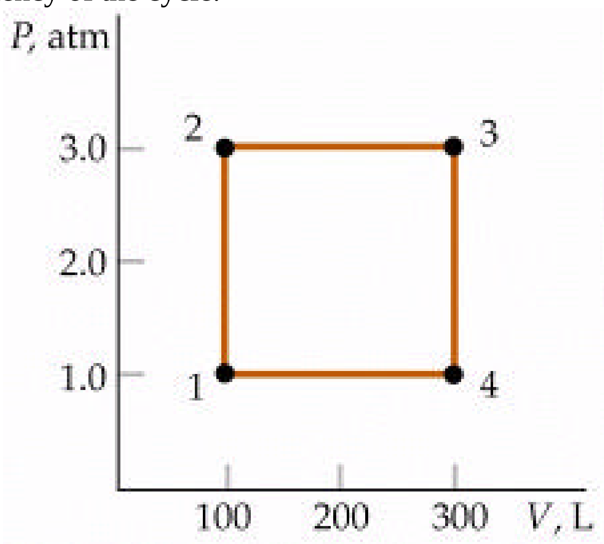
Chapter 20

**3** • John is house-sitting for a friend who keeps delicate plants in her kitchen. She warns John not to let the room get too warm or the plants will wilt, but John forgets and leaves the oven on all day after his brownies are baked. As the plants begin to droop, John turns off the oven and opens the refrigerator door, intending to use the refrigerator to cool the kitchen. Explain why this doesn't work.

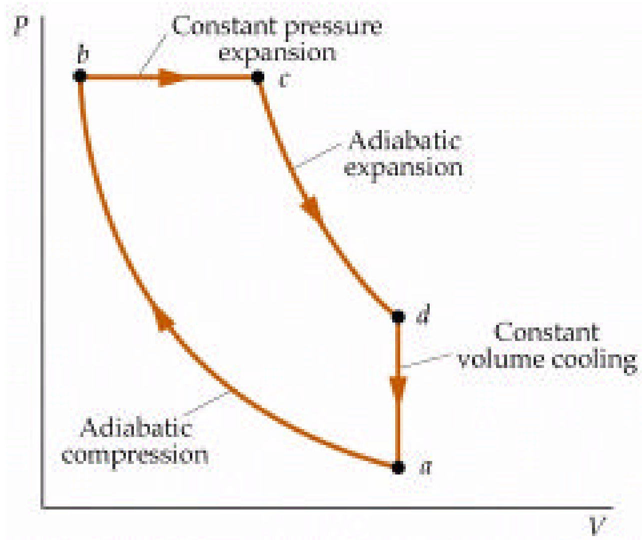
**4** • Why do power-plant designers try to increase the temperature of the steam fed to engines as much as possible?

**11** •• An engine using 1 mol of an ideal gas initially at $V_1 = 24.6$ L and $T = 400$ K performs a cycle consisting of four steps: (1) an isothermal expansion at $T = 400$ K to twice its initial volume, (2) cooling at constant volume to $T = 300$ K, (3) an isothermal compression to its original volume, and (4) heating at constant volume to its original temperature of 400 K. Assume that $C_v = 21$ J/K. Sketch the cycle on a *PV* diagram and find its efficiency.

**13*** •• An ideal gas ($\gamma = 1.4$) follows the cycle shown. The temperature of state 1 is 200 K. Find (*a*) the temperatures of the other three states of the cycle and (*b*) the efficiency of the cycle.



**14** ••• The *diesel cycle* shown approximates the behavior of a diesel engine. Process *ab* is an adiabatic compression, process *bc* is an expansion at constant pressure, process *cd* is an adiabatic expansion, and process *da* is cooling at constant volume. Find the efficiency of this cycle in terms of the volumes $V_a$, $V_b$, $V_c$, $V_d$, and $\gamma$.



**52** •• True or false:

(*a*) Work can never be converted completely into heat.
(*b*) Heat can never be converted completely into work.
(*c*) All heat engines have the same efficiency.
(*d*) It is impossible to transfer a given quantity of heat from a cold reservoir to a hot reservoir.
(*e*) The coefficient of performance of a refrigerator cannot be greater than 1.
(*f*) All Carnot engines are reversible.
(*g*) The entropy of a system can never decrease.
(*h*) The entropy of the universe can never decrease.

**53*** •• An ideal gas is taken reversibly from an initial state $P_i$, $V_i$, $T_i$ to the final state $P_f$ , $V_f$, $T_f$. Two possible paths are (A) an isothermal expansion followed by an adiabatic compression, and (B) an adiabatic compression followed by an isothermal expansion. For these two paths,

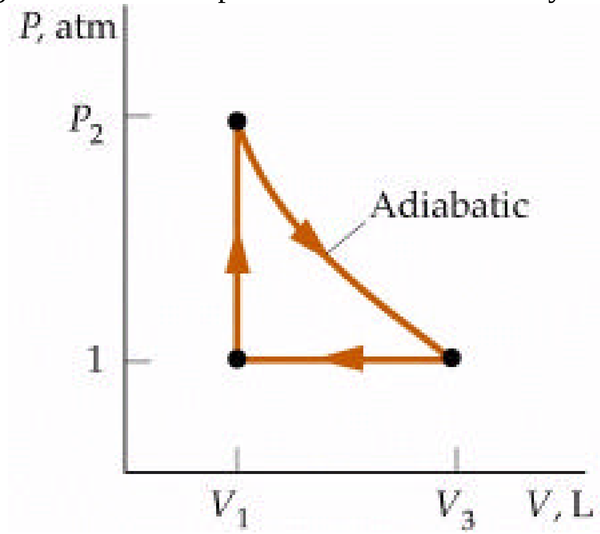
(*a*) $\Delta U_A > \Delta U_B$.
(*b*) $\Delta S_A > \Delta S_B$.
(*c*) $\Delta S_A < \Delta S_B$.
(*d*) none of the above is correct.

**8** • A refrigerator absorbs 5 kJ of energy from a cold reservoir and rejects 8 kJ to a hot reservoir. (*a*) Find the coefficient of performance of the refrigerator. (*b*) The refrigerator is reversible and is run backward as a heat engine between the same two reservoirs. What is its efficiency?

**18** •• A certain refrigerator takes in 500 J of heat from a cold reservoir and gives off 800 J to a hot reservoir. Assume that the heat-engine statement of the second law of thermodynamics is false, and show how a perfect engine working with this refrigerator can violate the refrigerator statement of the second law.

**24** •• A reversible engine working between two reservoirs at temperatures $T_h$ and $T_c$ has an efficiency of 20%. Working as a heat engine, it does 100 J of work in each cycle. A second engine working between the same two reservoirs also does 100 J of work in each cycle. Show that if the efficiency of the second engine is greater than 20%, the two engines working together would violate the refrigerator statement of the second law.

**27** •• In the cycle shown, 1 mol of an ideal gas ($\gamma = 1.4$) is initially at a pressure of 1 atm and a temperature of 0°C. The gas is heated at constant volume to $t_2 = 150$°C and is then expanded adiabatically until its pressure is again 1 atm. It is then compressed at constant pressure back to its original state. Find (*a*) the temperature $t_3$ after the adiabatic expansion, (*b*) the heat entering or leaving the system during each process, (*c*) the efficiency of this cycle, and (*d*) the efficiency of a Carnot cycle operating between the temperature extremes of this cycle.




**61*** • Which has a greater effect on increasing the efficiency of a Carnot engine, a 5-K increase in the temperature of the hot reservoir or a 5-K decrease in the temperature of the cold reservoir?

**63** • 20-63 An engine removes 200 kJ of heat from a hot reservoir at 500 K in each cycle and exhausts heat to a cold reservoir at 200 K. Its efficiency is 85% that of a Carnot engine working between the same reservoirs. (*a*) What is the efficiency of this engine? (*b*) How much work is done in each cycle? (*c*) How much heat is exhausted in each cycle?

Heat engine statement of the second law : It is impossible for a heat engine working in a cycle to remove heat from a reservoir and convert it completely into work with no other effects.

Refrigerator statement of the second law: It is impossible for a refrigerator working in a cycle to produce no other effect than the transfer of heat from a cold object to a hotter object.

**29*** • A heat pump delivers 20 kW to heat a house. The outside temperature is –10°C and the inside temperature of the hot-air supply for the heating fan is 40°C. (*a*) What is the coefficient of performance of a Carnot heat pump operating between these temperatures? (*b*) What must be the minimum power of the engine needed to run the heat pump? (*c*) If the COP of the heat pump is 60% of the COP of an ideal pump, what must the minimum power of the engine be?

Refrigerator statement of the second law: It is impossible for a refrigerator working in a cycle to produce no other effect than the transfer of heat from a cold object to a hotter object.

**30** • Rework Problem 29 for an outside temperature of –20°C.

**35** • Two moles of an ideal gas at $T = 400$ K expand quasi-statically and isothermally from an initial volume of 40 L to a final volume of 80 L. (*a*) What is the entropy change of the gas? (*b*) What is the entropy change of the universe for this process?

**36** • The gas in Problem 35 is taken from the same initial state ($T = 400$ K, $V_1 = 40$ L) to the same final state ($T = 400$ K, $V_2 = 80$ L) by a process that is not quasi-static. (*a*) What is the entropy change of the gas? (*b*) What can be said about the entropy change of the universe?

**38** • Jay approached his guru in a depressed mood. "I want to change the world, but I feel helpless," he said. The guru turned and pushed a 5-kg rock over a ledge. It hit the ground 6 m below and came to rest. "There," said the guru. "I have changed the world." If the rock, the ground, and the atmosphere are all initially at 300 K, calculate the entropy change of the universe.

**39** • What is the change in entropy of 1.0 kg of ice when it changes to water at 0°C and a pressure of 1 atm?

**83** ••• An insulated container is separated into two chambers of equal volume by a thin partition. On one side of the container there are twelve $^{131}Xe$ atoms, on the other side there are twelve $^{132}Xe$ atoms. The partition is then removed. Calculate the change in entropy of the system after equilibrium has been established (that is, when the $^{131}Xe$ and $^{132}Xe$ atoms are evenly distributed throughout the total volume).